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QUESTIONS OF THE TECHNOLOGY OF MINERAL RESOURCES IN PROSPECTING FOR DEPOSITS

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The need of the technological study of mineral resources in prospecting for deposits is widely known. Important technological properties which often determine the industrial value of the mineral resource depend on the mineral forms in which the useful ingredient is found, on the textural and structural singularities of the ore. These properties cannot be established by the data of chemical analysis.

The lack of knowledge of the technical properties of a mineral raw material is sometimes the source of big mistakes in the preliminary evaluation of a deposit and especially in determining the extent and direction of detailed geological exploratory works.

In this connection, the investigation of the technological properties of mineral resources and their technological evaluation must be regarded as an inalienable part of the geological exploratory operations in the case of every deposit.

These theses are at present perfectly clear to a wide circle in the geological service and do not need additional substantiation. Workers of the geological service are properly oriented by the question about heightened attention regarding the technological study of mineral resources in prospecting for deposits -- a question which has been raised in the pages of the magazine Razvedka i okhrana nedr (2).

In practice the geologist who organizes the technological study of the mineral resources for which he is surveying has to decide the following. (1) At what stage of the prospecting operations is it necessary to begin the technological sampling of the ore of the given deposit?; (2) what must be the content and extent of the technological investigations?; (3) how and in what quantity should specimens be selected for technological testing in connection with the degree of the prospecting, the deposit's singularities, exposed varieties of ore, and content of the technological tests?

An incorrect solution of each of these problems will lead to mistakes in the technological study of the mineral resources of new deposits.

In the present article we will dwell on the first of these problems. Its solution can be found only on the basis of correct accounting of the concrete singularities of the deposit, the type of mineral resource, and the state of the technology of its concentration and processing. Technological tests are usually begun in the period of detailed prospecting for the deposit: this does not always prove correct.

As a rule it is necessary to proceed from the position that technological tests which conform in detail to the degree to which the deposit has been subjected to prospecting and to the properties of the mineral resource must be completed at each estimate of reserves, which closes a definite stage of geological prospecting operations. If prospecting work and technological tests bring to light several types of ore which require various systems of concentration or treatment, the reserves of which are confirmed separately, then the data of the technological investigations must be at the disposal of the prospector considerably earlier --

at the period of sampling the deposit and estimating the reserves.

If the industrial value of the mineral resource is not sufficiently clear (e.g., a kind of raw material not yet processed by industry, ore with a low content of the mineral ingredient, or others), then its technological evaluation must be known to the prospector still earlier -- at the stage of preliminary surveying, so that a correct idea of the industrial value of the deposit may be more rapidly obtained.

Study of the technological properties of a mineral resource, which are found in complex dependence on its genetic and textural-structural peculiarities, cannot always be limited to standard tests. In the methodological approach, technological investigations are very far removed from chemical analyses, in which for every ingredient being determined several standard methods can be created, embracing the main mass of the mineral complexes being analyzed. The fineness of grinding the ore before concentration, the systems of ore concentration, reagent conditions of flotation -- these seldom coincide for separate ores. They must be selected experimentally on the basis of the analysis of many facts.

Tests of ore separability, for example, usually entail the experimental study of several methods of concentration and the effect of many factors on its indices. They are often accompanied by labor-consuming methodological investigations. The metallurgical tests are also often extremely complex.

But when should the technological tests be started? Of course the sooner, the better. When the geologist learns of the technological characteristic of the ore, in accordance with the degree of discovery by prospecting operations of industrially important quantities of

separate varieties of a mineral resource at separate sections and levels of the deposit, he can more substantially, rapidly, and economically conduct the prospecting operations, can better prepare the reserves of the deposit for which he has prospected for confirmation in accordance with instructions on the classification of reserves.

The complex work of the geological prospecting party or expedition and the concentration or technological laboratory -- this represents the best form of organizing geological explorations, at the time creating the necessary conditions for the most rapid and inexpensive prospecting of deposits, for positive technological evaluation of the resultant reserves, and for the most rapid full confirmation of reserves.

Under such organization of operations, the technological type of the mineral resource which requires separate estimating can be established opportunely. Expenditures in time can be curtailed in prospecting for those mineral resources or their types, the technological properties of which prove unsatisfactory.

The best organizational form of such complex work of the geological prospecting party or expedition and the concentration or technological laboratory has already been made manifest by the experience of the geological service. The presence of proper concentration and technological laboratories that work unifiedly with geological prospecting parties and expeditions in the system of territorial geological administrations makes possible the successful solution of this problem. The experience of the work of a concentration laboratory and a laboratory of nonore minerals of the Ural geological administration (1, 4) confirms the correctness of such a form of the organization of technological tests.

In its decrees the Ministry of Geology and Conservation of Natural Resources USSR has set a time for organising technological laboratories in the territorial geological administrations. However, the rate of realising these decisions is inadequate. Apparently, in the local centers tendencies are still not yet overcome at some places to consider that the technological study of mineral resources is a matter complicated in methodologic and organisational respects, and that it is best to assign it to some kind of specialised institute: Mekhanobr, Uralmekhanobr, VIMS, etc.

The perversity of such tendencies in the presence of the ever-growing volume of geological prospecting is clear. The larger the portion of technological tests assigned to the institutes, the more difficult it is to secure their fulfillment without delay. This has a negative effect on the times of preparing reserves for confirmation. In practice many geological prospecting parties and expeditions at present do not yet have their own laboratory bases. The technological testing has to be included in the thematic plan of the institutes.

Now, when is it inexpedient but extremely necessary to begin without further delay technological investigations?

The basic factor that determines the choice of the time for the beginning of technological tests is, in these conditions, the degree to which industry has mastered the mineral resource being prospected for.

The simplest case is the prospecting for a mineral resource, the technology of concentration and processing of which has been mastered by industry. Examples of such a raw material are rich magnetite ores treated without concentration; coarsely disseminated cassiterite ores; large and medium grained quarts-fluorite ores;

phosphorus, sulfur and silicon limestones conditioned in content; disseminated sulphide copper ores with conditioned content of metal, etc.

In this case -- which is simplest for the prospector -- the technological tests can be started in the stage of detailed prospecting for the deposit. The task of the technological tests from their very first stage must be technological evaluation -- evaluation of separability for ores to be concentrated; evaluation of metallic, ceramic, and other properties of ore and rock that are not subject to concentration.

For confirmation of the reserves of certain mineral resources of this group (Category C_1) the instructions of the Ministry of Geology and Conservation of Natural Resources allow an evaluation of their quality without experimental work, by analogy with explored deposits.

The prospecting for a new type of mineral raw material, the concentration and processing of which has not yet been mastered by industry, is another case. Such a task can arise in connection with the discovery of large reserves of a kind of mineral raw material new to industry, when at the same time reserves of a mastered raw material are short in a given district or in the country as a whole. Sometimes the need to utilise new mineral forms of various mineral components arises in the complex character of the ore in which are found side by side mastered types of mineral raw materials and contents of other mineral components worthy of attention in forms of deposits not yet mastered.

Tin ores, in which the tin is confined in stannin, can be cited as an example. Concentration of them in order to obtain stannin concentrates and the metallurgical working of the latter

have not yet been mastered by industry. It is approximately the same in the case of ores that contain beryllium in the form of phenacite, etc.

The technological investigation of mineral resources not yet mastered by industry must be started very early, e.g., as soon as it is found (if only in consequence of the prospecting operations) that the reserves of such resources in the given deposit are sufficiently large. This is necessary in order to determine the expediency of commencing prospecting operations, and also the extent and tempo of such operations.

The tasks of technological investigations in this very complex case are somewhat different than in the first instance. Taking into account the conditions of the given deposit, it must be ascertained whether it is technically possible and economically expedient to utilize the new kind of mineral raw material. Only on the basis of timely preliminary technological and economical evaluation and the data of the prospecting operations can the question of the expediency, direction, and extent of the geological prospecting operations be correctly solved.

These 2 cases can be considered extreme in the practice of geological prospecting work. There is also a number of intermediate-type cases.

For example, the deposit of a mastered mineral resource is being prospected for. However, in view of the complexity of its substantive composition or the poorness of the mineral ingredient, its concentration or chemicometallurgical processing can be so complicated or expensive that without experimental study it is impossible to establish whether industrial use of the deposit is expedient.

Examples of such ores are the ores of the usual composition, but with fine dissemination of mineral resources or with low content of them: lead-copper-zinc ores hard to concentrate, calcite-fluorite ores with considerable content of carbonates, iron ores containing apatite, titano-magnetite ores with an inadequate content or titanium, etc.

The technological study of such ores must already begin in the stage of the preliminary, or at the beginning of the detailed prospecting. The task of the investigation must be the working out of a system of concentration or processing of the mineral resource and the determining of the technical economical indices of these processes.

Concentrates of a definite mineral resource, conditioned in content of mineral ingredients and noxious impurities, have been mastered by industry. However, the ores of the deposit being prospected for are characterized by a mineral complex, concentration of which has not been mastered. For example, barite and hematite are contained in fluorite ores; or fluorite, beryllium, and turmalin are contained in tin ore. The working out of a system of concentrating ores with a new mineral complex is more involved and requires a larger volume of tests than is the case of ores of a mastered composition.

Upon concentration, ores render concentrates which in part do not meet the established conditions (new impurities or special physical properties: sheelite concentrate contains more phosphorus than it should; more silica appears in magnesite concentrate from talc-magnesite rocks than is established for it by technical standards.

And in these cases the technological tests must be started at the beginning of detailed, or even in the stage of preliminary prospecting.

The influence of the degree to which a mineral raw material has been mastered on the determination of the time for beginning the technological tests is shown schematically in the following table.

[See table on page 10]

As follows from the foregoing, for a sound solution of the problem of when the technological investigations of mineral resources being prospected for must begin, it is essential to know:

(1) the technical demands that various branches of industry make in regard to the raw material under survey and its concentrates with respect to content of mineral ingredient, noxious impurities, granulometric composition, moisture content, and other conditioning properties;

(2) the mineralogical characteristic, quantitative distribution of the mineral ingredient in mineral forms, the character of the dissemination of mineral resources and empty rock, the textural-structural regularities of ores, the chemical composition of the main varieties of ores;

(3) the methods of concentration and chemico-metallurgical processing of the mineral resource being prospected for and also the effect on the indices of the concentration and processing of possible impurities and of the ore's physical properties;

(4) the degree to which industry has mastered the methods of concentration and chemical, metallurgical, or mechanical processing of the mineral resource, and also the results of research work in this field.

CHART OF DEPENDENCE OF BEGINNING OF TECHNOLOGICAL TESTS ON THE DEGREE TO WHICH A GIVEN KIND OF MINERAL RAW MATERIAL HAS BEEN MASTERED

Characteristic of the mineral resource	The stage of prospecting operations not later than which technological tests must be started	Task of the first stage of the technological tests
Technology of concentration and processing mastered by industry	Detailed prospecting	Technological evaluation of the mineral resource
Technology of concentration and processing mastered, but system of concentration or processing is complex or expensive	Beginning of detailed or preliminary prospecting	Working out of a rational system of concentration or processing. Determination of technical-economic indices of concentration and processing
Technology of concentration is not mastered by industry	Preliminary or beginning of detailed prospecting	To get conditioned concentrates with acceptable technical-economic indices
Technology of concentration is mastered, but processing of concentrates or mineral resource (if it is not concentrated) has not been mastered by industry	Preliminary or beginning of detailed prospecting	System of processing the mineral resource or its concentrates with changed conditions. Obtaining of technical-economic indices
Technology of concentration and processing has not been mastered by industry	Exploratory prospecting or preliminary surveying work	Preliminary technological and economic evaluation of the new kind of mineral raw material

The geologist can obtain a portion of the necessary data irrespective of the degree to which the deposit has been subjected to prospecting and study, although serious work on his part is required, desirably in consultation with the concentrator, metallurgist, or ceramic expert.

In this respect, the geologist can be greatly aided by familiarity with the appropriate issues of the series of manuals of VIMS: Trebovaniya promyshlennosti k kachestvu mineral'nogo syr'ya [Demands of Industry on the Quality of the Mineral Raw Material] (5). Useful data can be extracted by the geologist from the general manuals of Mitrofanov (3), Sidorov (4), and Bygeles (6) and also from special literature.

Appropriate material must be collected, systematized, and generalized during the drawing up of the project of prospecting operations. However, a large part of the data essential to the geologist for solution of the question regarding the time to begin the technological tests can be ascertained only during concrete geological-mineralogical study of the deposit and the chemico-mineralogical study of the mineral resource.

Sometimes the complete chemico-mineralogical investigation of mineral resources is complex and prolonged. This can result in a condition in which the geological surveyor finds himself without sufficient data for opportune solution of the problem of when it is actually necessary to begin the technological tests.

In this case the problem should be solved by combining the chemico-mineralogical and technological investigation of the mineral resources. This means that the technological investigation has to begin immediately after reserves of industrial scale have been found,

without waiting until the chemical and mineralogical investigation creates firm bases for solution of the problem of when it is actually necessary to begin the technological tests.

Such combined operation is most feasible and most convenient, as the experience of separate laboratories shows (1, 4) in the foregoing case, when the territorial geological administration, party, or expedition which is prospecting for the deposit, has in its composition concentrating, chemico-metallurgical, nonore, and other technological laboratories.

The latter, working close to the territory in which the geological prospecting is being done, can maintain direct contact with the geological prospectors and be active participants in the prospecting for the deposit. Their work, just as the work in sampling specimens, must be included in the project and estimate of the prospecting operations.

Unfortunately, the network of technological laboratories in the system of the geological service is still inadequately developed, poorly equipped, and not yet strong in respect to method.

Manifold development of the technological laboratories of the territorial geological administrations is one of the best means for the rapid solution of the multiform problems of the technological investigation of mineral resources subject to prospecting operations.

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